REPORT
ON
STREET LIGHTING
IN THE
CITY AND COUNTY OF SAN FRANCISCO

AUGUST 1963

BUREAU OF ENGINEERING
DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF SAN FRANCISCO

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DEPARTMENT OF PUBLIC WORKS

OFFICE OF THE
DIRECTOR OF PUBLIC WORKS

260 CITY HALL
SAN FRANCISCO 2,
CALIFORNIA

August 26, 1963

1361
Street Lighting Report
Transmittal

Through: Mr. Sherman P. Duckel
Chief Administrative Officer

Board of Supervisors
City and County of San Francisco
235 City Hall

Attention of Mr. Robert J. Dolan
Clerk of the Board

Gentlemen:

We are pleased to submit fifteen copies of our "Report on Street Lighting in the City and County of San Francisco" dated August, 1963. The study upon which this report is based was financed with funds appropriated in the 1962-63 budget pursuant to a request by Supervisor Joseph E. Tinney and a recommendation included in the Joint Report on City and County of San Francisco Street Lighting dated May 7, 1962, prepared by the Department of Public Works and the Public Utilities Commission.

The findings, conclusions and recommendations included in this report were previously summarized in our letter to your Board dated June 17, 1963. Also included are the factual data and analyses from which the conclusions and recommendations were determined.

If you concur with the recommendations, the Department of Public Works will initiate the administrative and legislative actions necessary to implement the proposed program.

The staffs of the Power and Utilities Engineering Bureau and of the Pacific Gas and Electric Company were especially helpful in the gathering of information included in the report and provided other valuable assistance during its preparation. Their efforts are greatly appreciated.

We will, of course, be happy to provide any additional information you may require or answer any questions that may arise during your study of the report.

Very truly yours,

Clifford J. Scott

FOR S. M. Tatarian
Director of Public Works

Attach: Report (15)

Report on street lighting in the City 1963.

REPORT

ON

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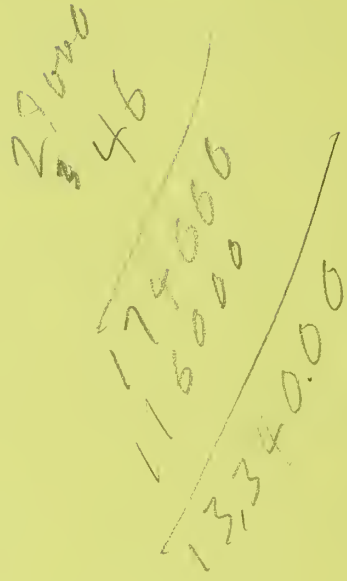

2,000
346
17,666
16,000
13,340.00


29
13340
13660

I Major Findings, Conclusions and Recommendations

The results of the recent street lighting survey for the City and County of San Francisco can be summarized as follows:

Findings

1. There are now approximately 29,000 street lights in service.
2. About 11,000 are City-owned or jointly-owned and about 18,000 are owned by the Pacific Gas and Electric Company.
3. Forty-six percent of the street lights are in overhead districts which cover eighty-two percent of the total street mileage.
4. Fifty-four percent of the street lights are in underground districts which cover eighteen percent (165 miles) of the total mileage (910 miles) of City streets.
5. Overhead district illumination level averages about forty-eight percent of the desirable minimum.
6. Mercury vapor lamps are the most economical.

Conclusions

1. In overhead districts, private ownership of street lights is more economical than City ownership.
2. In underground districts, City ownership is more economical.

Recommendations

1. Adoption of "American Standard Practice for Street and Highway Lighting" of the American Standards Association as a guide for planning street lighting improvements.
2. Use mercury vapor lamps exclusively.
3. Continue private ownership of street lights in overhead districts.
4. Convert from private to City ownership in underground districts by:
    a. Installing City-owned systems in new underground districts;
    b. Replacing privately-owned systems that were installed prior to 1941.
    c. Replacing other privately-owned systems when they become inadequate or obsolete.
5. Direct Pacific Gas and Electric Company to bring illumination levels in overhead districts into conformity with adopted standards.
6. Continue present practice of financing lighting system installations in new underground districts from gasoline taxes.
7. Submission of a $7,000,000 bond issue to the voters for approval to finance the replacement of privately-owned systems (installed prior to 1941) and City-owned systems that are either physically deteriorated or inadequate.
8. Transfer of all street lighting functions, except payment of bills for energy, from Public Utilities Commission to Department of Public Works.

II

GENERAL

II General

The report prepared jointly by the Department of Public Works and the Public Utilities Commission dated May 7, 1962, recommended that a study be made of the existing street lighting system to determine the magnitude of the modernization and rehabilitation program required, the priorities of the improvements needed and methods of financing.

As of June 30, 1962, there were 29,134 street lights[1] in operation in San Francisco. Of this total number, 18,288 units are owned by the Pacific Gas and Electric Company, 9,287 units are City-owned and 1,559 units are jointly-owned.

The total number of street lights also can be subdivided into 13,373 units supplied by overhead wiring and 15,761 units supplied from underground circuits. While most of our street lights are in underground districts, these districts cover only 165 miles out of 910 miles of dedicated streets. Thus fifty-four percent of our street lights are in eighteen percent of our streets.

The problem of lighting adequately the eighty-two percent of our streets that lie in overhead districts is by far the most important part of the survey. It is perhaps a coincidence that approximately eighty-five percent of the complaints about street lighting were received from residents of overhead districts.

The street lights in the underground districts present a different problem. The existing systems are of varying ages and effectiveness. Some provide adequate lighting, many do not

[1] A street light is counted as one unit whether it has one, two or three l ght sources.

and also are in bad physical condition. As will be shown, it is often possible to replace an aged inadequate system owned by the Pacific Gas and Electric Company with a modern, adequate City-owned system at a saving in annual cost.

The underground districts grow at the rate of 2-1/2 miles per year. In recent years, this has been the only place where the street lighting has been improved. It seems unlikely that there will be any change in the underground district policy as any sudden increase in mileage would have considerable effect on utility rates.

In order to determine the extent of the improvements needed in our street lighting systems, it is necessary to establish standards of performance. Furthermore, the cost is an important factor that must be carefully analyzed before any estimates can be made. It is intended, therefore, to:

1. Establish standards for the intensity and quality of illumination based on street use and police reports.
2. Determine costs of street lighting.

Consequently, this study is divided into four separate sections thusly:

a. Standards of illumination;

b. Costs of street lighting;

c. Recommendations for the improvement of the street lighting systems;

d. Estimate of the cost of rehabilitation of old City equipment and replacement of obsolete Pacific Gas and Electric Company Systems.

III

STANDARDS OF STREETLIGHTING

III Standards of Street Lighting

There is no recognized code for street lighting design in the sense of the Uniform Building Code or the National Electrical Code. The illuminating Engineering Society has, however, prepared a pamphlet which has been adopted by the American Standards Association as the American Standard Practice for Street and Highway Lighting.

It is recommended that the City use the American Standards Association American Standard Practice for Street and Highway Lighting as a guide in planning street lighting systems. It is understood that these standards will be revised and that methods of illumination will improve with time. Consequently, the design of future street lighting systems should be in accordance with the latest approved practice.

The basic recommendations are as shown in Table I.

TABLE I

Current Recommended Average Horizontal Footcandles*

Pedestrian Traffic	Vehicular Traffic Classification				
	Very Light Under 150	Light 150-500	Medium 500-1200	Heavy to Heaviest 1200 Up	
Heavy	———	0.8	1.0	1.2	
Medium	———	0.6	0.8	1.0	
Light or None	0.2	0.4	0.6	0.8	

*Minimum Values (footcandles)

Figures under vehicular traffic classification are cars per hour during peak flow in darkness. A great many residential streets carry more than 150 cars per hour during a peak hour. Furthermore, good engineering practice requires some anticipation of the future. Street lighting design as related to traffic density should take into account the trends observed by the Traffic Engineer.

In formulating its recommendations for street lighting, the Illuminating Engineering Society was primarily concerned with the reduction of night traffic accidents. For this reason, their recommendations provide for illumination in proportion to traffic volumes. The minimum recommended levels are supposed to be satisfactory for security. The Illuminating Engineering Society Handbook (Third Edition) page 20-1 lists six additional and equal purposes of street lighting as follows:

1. To enhance civic pride and community value of the streets.
2. To increase the attractiveness of the streets.
3. To offer protection against annoyance and property damage.
4. To provide comfort and convenience.
5. To add a sense of security for those who use the roadways at night.
6. To contribute a deterrent to crime.

It is further recommended in the Standard Practice that the lowest footcandle level at any point on the pavement should not be less than one-fourth the average value given in the table. An exception is made in this requirement for roadways carrying very light vehicular traffic where the lowest footcandle value at any point may be as low as one-tenth the average value in the Table. This last exception results in non-uniform lighting, of course.

The Standard Practice also states that the footcandle values listed in the Table be increased where pavement reflectance is low. Most of San Francisco's streets have black asphalt wearing surface with low reflectance.

It is important also to have a reasonable level of illumination on sidewalks and roadside areas. This will usually result when the Standard Practice is followed.

Light Sources

Adequate street lighting can be obtained by the use of incandescent, mercury-vapor or fluorescent lamps. The choice should be made on an economic basis.

It was found in preliminary analysis that mercury-vapor lamps were the most economical source for use in San Francisco. Consequently, only mercury-vapor sources were considered in the preparation of the recommendations of this report. The actual economies are shown in the sections on the costs of street lighting. The reasons for this choice can be summarized as follows:

1. Mercury-vapor lamps are more than twice as efficient as light sources than incandescent lamps.
2. Use of sources of high output allows maximum desirable spacing of electroliers.
3. Lamp life is extremely long by comparison with incandescent lamps.
4. Light output for the same energy input is being improved yearly.
5. Color is being constantly improved along with increase in light output.
6. Use of regulated-type ballasts permits economical low voltage service and gives greatest advantage in choice of rates.
7. Energy saved in street lighting can be sold by Hetch Hetchy, adding revenue and, in effect, reducing costs of street lighting.

Design Criteria

Having made the choice of a light source, it is a simple matter to apply the recommendations of the Illuminating Engineering Society to a number of San Francisco streets taken at random. The results of this application are given in Table II. (See Appendix A for principles of calculations). In addition to the minimum recommendations of the Illuminating Engineering Society, some weight was given to the desirability of more light on primary business streets and streets having public transportation where passengers must wait.

Streets are, therefore, grouped in the following categories for which suggested average illumination levels are given:

A. Major Business

Streets of greatest distinction. Lighting for appearance of street as well as safety. High intensity illumination which lights building fronts as well as street Heavy pedestrian use at night as in downtown shopping. Traffic over 1200 cars per hour and heavy pedestrian volume.

Over 1.2 footcandles

B. Major Thoroughfare Plus Business

Streets having businesses and large traffic volumes. Fewer pedestrians at night than Category A. Business largely motels, restaurants and apartment houses. Two or more lanes of traffic in each direction. May have center island or be one-way. Desirable to have considerable light on sidewalk.

Determine illumination level
on traffic volumes. 0.8 - 1.5 footcandles

C. Major Thoroughfare Plus Residential

Similar to Category B except desirable to keep light off fronts of buildings. Usually on outlying parts of Category B. Could use lower illumination level based on traffic volume. May have center island or be one-way.

Determine illumination level
on traffic volumes. 0.6 - 1.2 footcandles

D. Secondary Business

Neighborhood shopping areas and theatres. Low traffic volume and pedestrian density. Considerable parking. Lighting for pedestrian security. Areas subject to petty theft and vandalism, particularly on parked cars. May have public transportation and consequent waiting areas.

0.8 - 1.0 footcandle

E. Industrial and Commercial

Areas with little night traffic. Need for police protection. Occasional bar or restaurant open late. Building maintenance people work late. Prime areas for burglary, especially of warehouses. Need sufficient light to see loiterers or suspicious vehicles.

0.2 footcandles minimum -
More if justified by traffic
volumes or Police reports

F. Residential (Apartment Houses)

Little night traffic but densely populated. Usually many parked cars subject to theft or vandalism.

0.3 - 0.4 footcandles average

G. Residential (Single Family)

Little night traffic. Sometimes trees or shrubbery. Critical of light on building fronts or windows. Occasional pedestrians walking from public transportation or exercising dogs. Likely location for holdups, molestations and attacks.

0.2 to 0.3 footcandles average

Since it is intended that electrolier spacings be essentially the same for all categories, the illumination level can be changed to suit changes in street use at minimum expense. Furthermore, the establishment of street lighting categories provides a logical basis for the evaluation of complaints.

Recommended Standards of Street Lighting

Based on the foregoing conclusions regarding light sources, categories of street use and the Recommended Practice of the American Standards Association, it is recommended that:

a. Sources be mercury-vapor lamps.
b. Luminaire spacing be approximately five times the mounting height.
c. Mounting height be approximately thirty feet.
d. Average illumination be in accordance with the suggested minimum levels for the street lighting categories listed herein.
e. Average illumination on intersections be approximately the sum of the average illumination on the intersecting streets.
f. Increases in illumination levels shall be determined by increasing output of source rather than increasing number of luminaires and poles.

	rvey 3-21-63
DISTRIC	
Grant A	
Powell	
Broadwa	
Harriso	
Fulton	
17th St	
Pine St	
Polk St	
Clement	
Brannan	
Main St	
Ellis S	
Vallejo	
Shotwel	
Kirkham	
27th Av	

S/L Survey 3-21-63

TABLE II

STREETLIGHTING DESIGN CRITERIA

DISTRICT	Street Dimensions		Traffic Volume Peak	Ped. Volume	Street Category	Proposed Lamp	Spacing	Maint. Ft.C.	REMARKS
	Block Length	Pavement Width	Cars/Hr.						
Orant Ave., Market to Bush	275	44.	470	Heavy	A	700W	137.5	1.9	
Powell St., Market to Calif.	275	38.	200	Heavy	A	700W	137.5	2.0	
Broadway, Columbus to Davis	412.5	52.5	1400	Heavy	B	700W	137.5	1.7	
Harrison St., 5th to 10th	825	52.5	1400	Light	B	400W	165.	.70	
Fulton St., Stanyan to 48th	240	50.	800	Light	C	400W	120.	1.0	
17th St., Market to Clayton	560	34.	800	Light	C	400W	140	1.1	
Pine St., Van Ness to Davis	412.5	38.75	1300	Med.	C	400W	137.5	1.0	
Polk St., Sutter to Vallejo	275	38.75	500	Heavy	D	400W	137.5	1.0	
Clement St., 1st to 12th	240	50	450	Med.	D	400W	120.	1.1	
Brannan St., 2nd to 8th	825	52.5	700	Light	E	175W	165.	.2	
Main St., Mission to Bryant	550	52.	350	Light	E	175W	162.5	.2	
Ellis St., Franklin to Laguna	412.5	38.75	220	Light	F	175W	137.5	.34	
Vallejo St., Lyon to Van Ness	412.5	38.75	175	Light	F	175W	137.5	.33	
Shotwell St., 16th to 24th	520.	30.	75	Light	F	175W	185.	.39	
Kirkham St., 7th to 48th	240.	50.	200	Light	G	175W	120.	.32	
27th Ave., Lincoln to Ulloa	600.	40.	100	Light	G	175W	200.	.22	

IV

COSTS OF STREETLIGHTING

IV Costs of Streetlighting

For many years, there have been advocates of City ownership of the streetlighting systems (*). However, for a number of reasons, mostly financial, City ownership has grown very slowly. In the meantime, a complicated set of rate schedules has been created. The problem of the most satisfactory ownership must be decided before any estimates of the cost of the streetlighting system can be made.

Under present arrangements, streetlighting installations can be made by the simple expedient of issuing an order to the Pacific Gas and Electric Company. A great many combinations of light standards and luminaires are provided in the established rate schedules. No capital investment by the City is required.

On the other hand, the Department of Public Works could prepare plans and specifications and award contracts for the installation of City-owned streetlighting systems. These projects could be financed by annual budget appropriations each year from gasoline or ad valorem taxes or by a bond issue.

Which way is better? Only a careful study of the existing rates can show.

(*) Annual Report of the Bureau of Engineering 1928-1929 -- p. 19.

Resolution of the Public Utilities Commission No. 13,526 dated June 22, 1953.

Computation of Costs

The total annual cost of a streetlight is the sum of the following factors:

a. Annual Cost of Investment (i.e. Bond Interest and Redemption)
b. Charges by Utility Company for services (i.e. switching)
c. Cost of energy
d. Cost of maintenance.

To these costs must be added the cost of administration of any contracts with the Utility Company or a Maintenance Contractor. Since this cost is independent of the particular kind of streetlight or rate schedule, it makes no difference in the determination of the lowest total annual cost of a streetlight.

The investment in a streetlight is the sum of the planning, design, installation and inspection costs. For a City-owned system financed by bond funds, the investment should be amortized in 15 years at 3-1/2% interest. This is the basis for determining investment costs in this report. For the purposes of comparison with Pacific Gas and Electric Company-owned systems, the total investment cost has been averaged over the estimated 30-year life of a system. Estimated investment costs for a variety of streetlighting types and installations based on construction prices bid under recent contracts are tabulated in Appendix B.

There is, of course, no capital investment required by the City for streetlighting systems owned by the Pacific Gas and Electric Company. However, the costs of the Company's investment are included in the rates bid for streetlighting service.

Each year, the Public Utilities Commission awards a contract to the Pacific Gas and Electric Company for the furnishing of streetlighting service. This contract lists unit prices for all kinds of streetlights arranged in any of fifteen types of system. The unit prices include investment charges for company-owned systems, service charges for all systems, energy and maintenance for company-owned systems. The maintenance of City-owned systems is done under a separate contract let by the Public Utilities Commission annually to the lowest bidder.

Hetch Hetchy energy is used for all streetlights. Consequently, the Pacific Gas and Electric Company gives the City a credit of $.01345 cents per kilowatt hour for the energy used in all streetlights regardless of ownership. However, the Public Utilities Commission then pays the Pacific Gas and Electric Company $.006421 per kilowatt hour for delivering the energy to the streetlights plus charges for losses amounting to as much as 18% of the energy delivered for some systems.

Cost Analysis

As pointed out earlier in this report, there is a great difference between the level of illumination provided in overhead and underground districts. Furthermore, nearly all of the lighting in overhead districts is owned by the Pacific Gas and Electric Company. Since most complaints originate in the overhead districts, and the most expensive systems are in the underground districts there are two separate problems. The first is the improvement of streetlighting in overhead districts. The second is

the modernization and rehabilitation of the streetlighting in underground districts. In many instances, it is possible to improve the lighting in the underground districts and actually reduce the annual cost. For these reasons, the overhead and underground districts are considered separately.

A. Overhead Districts

Since about forty-six percent of our streetlights are located in eighty-two percent of our streets, it is of interest to get an idea of just how well the City is lighted on the average in the overhead districts. As a first approximation, the general lumens per square foot approach described in Appendix A may be employed.

If it is assumed that the 745 miles of streets in overhead districts are 40 feet wide and should be lighted to 0.2 foot-candle; then

$$5280 \times 745 \times 40 = 157{,}344{,}000 \text{ sq. ft.}$$

$$\frac{157{,}344{,}000}{.28} \times 0.2 = 112{,}390{,}000 \text{ lumens}$$

If 175 watt mercury vapor lamps were to be used throughout the overhead districts, each giving 7500 lumens; then

$$\frac{112{,}390{,}000}{7500} = 15{,}000 \text{ streetlights would be required.}$$

The existing streetlights in use in overhead districts are as follows:

PB	290	units at	2500	lumens	=	725,000
PB	8593	" "	4000	lumens	=	34,372,000
PB	329	" "	6000	lumens	=	1,974,000
OB	18	" "	2500	lumens	=	45,000
OB	4130	" "	4000	lumens	=	16,520,000
OB	13	" "	6000	lumens	=	78,000
Total	13,373			Total		53,714,000 lumens

PB = Pendent bracket (Modern)
OB = Ornamental bracket (Obsolete)

Thus, the existing 13,373 streetlights supply only forty-eight percent of the minimum requirements assuming, of course, that all overhead districts should be lighted to the minimum level, which is not true. Actually, much more light is required but, at this point, the analysis is intended only to establish the order of magnitude of the minimum requirements.

Of course, the illumination requirements could be satisfied with incandescent units. Where 15,000 mercury vapor units might be adequate, at least 28,000 incandescent units of 4000 lumens each would be required for minimum lighting.

Again, it is emphasized that these are minimum requirements. As previously stated, the calculations are intended to be a first approximation to the actual needs and to establish the fact that more illumination is needed in overhead districts.

The basic problem in the overhead districts is how to get at least double the amount of light for the least cost. At first glance, it would appear that doubling the illumination should double the cost.

Preliminary analysis indicated that there are savings possible by City-ownership of the streetlighting in overhead districts. Two schemes are possible:

1. The City could install streetlights on the existing Utility Company poles, or
2. The City could install a separate set of steel poles with streetlights fed by overhead service from the Utility Company's lines.

Scheme (1) might involve the City in an extensive construction program as it is doubtful that the Utility Companies would allow a Contractor's forces to work on their poles.

Scheme (2) has been used successfully in other Bay Area cities but certainly would not improve the appearance of most of our streets in overhead districts. For this scheme, additional poles and wires spanning the streets would be necessary.

Despite these disadvantages, there appeared to be money to be saved. Consequently, our analysis was discussed with officials of the Pacific Gas and Electric Company. After considerable study and discussion, the Company offered a 28% reduction in its rate for the 175 watt mercury-vapor unit on a wood pole. As a result of this reduction, the 175-watt mercury-vapor luminaire

producing 7500 lumens could be had for the price we are now paying for the 4000 lumen incandescent units. This reduction in rate is possible due to improvements in operation methods and a decrease in the price of mercury-vapor streetlighting luminaires.

The cost analysis is shown in Table III. Although the rates are the same for the 4000 lumen incandescent and 175-watt mercury-vapor units, the latter is more profitable to the Company due to the lower energy consumption. However, when the taxes paid by the Company are included, it is apparent that their offer is to the City's advantage.

It is recommended that the Public Utilities Commission modify the annual contract with the Pacific Gas and Electric Company and immediately proceed with the conversion of luminaires. In this way, most of our complaints will be satisfied at no immediate increase in the annual budget.

The low rate shown in Table III for the 175-watt mercury-vapor unit is based on the estimated quantity of 15,000. Rates for other lamps must be taken from the rate schedules.

Examination of Table IV shows that City ownership of the streetlights in overhead districts is advantageous for the larger luminaires. However, the majority of streetlights will be of the low cost 175-watt rating. It would be impractical for the City to own a small part of the streetlights in overhead districts if they were installed on the Utility Company's poles.

The possibility of City ownership in overhead districts through the use of a separate set of steel poles was studied and the results tabulated in Table IV.

AET 2-20-63

	NOTES
LUMENS OUTPUT	(#1) Includes 18% line loss.
RATE SCHEDULE	(#2) $.01345 per KWH credit to
RATE PER NIGHT	Hetch Hetchy. See appendix B.
	(#3) $.006421 per KWH for delivery of
ANNUAL PAYMENT TO PG&E CO.	energy paid to PG&E. see appendix B.
	(#4) 16000 hour rated life. Relamp at
WATTS	1200 hours (3yr.), price from
ANNUAL KWH	current contract.
	(#5) Based on previous years contract.
ENERGY CREDIT TO CITY BY PG&	(#6) Includes planning, construction
PAYMENT TO PG&E CO. FOR WHEE	and inspection.
TOTAL NET PAYMENT TO PG&E CO	(#7) 3½% interest for 15 years averaged
BURN-OUTS, BROKEN GLASS	over 30 year life.
ANNUAL RE-LAMPING (#4	(#8) See appendix B-4
ANNUAL MAINTENANCE (#5	(#9) Not in rate schedule. Quoted by
PAYMENT TO MAINTENACE CONTR.	PG&E Co. 1-25-63.
	(#10) Assume administration and
ANNUAL COST	supervision now in employ of PG&E Co.
	would be required if city performed
UNIT CAPITAL INVESTMENT BY (	work. Prorated in direct proportion
AVERAGE COST OF INVESTMENT (	that overhead districts are to
	total PG&E streetlights
AVERAGE TAXES (30yr.) (#	$\frac{13339}{18288} = .73$
	.73 supervisor at 6000(partial) 4380
ADMINISTRATION (#	.73 clerk at 6000 4380
	.73 gen. foreman at 11000 8000
NET ANNUAL COST (CONTRACTU	$16760
HETCH HETCHY COST (#	$\frac{16760}{13339} = \$1.25$ per streetlight
	(#11) Energy Credit Less Wheeling
	Costs
TOTAL ANNUAL COST (NET	

AET 2-20-63

TABLE III

COMPARISON OF COSTS OF STREETLIGHTING IN RESIDENTIAL AREAS (OVERHEAD SERVICE)

	WOOD POLES 4000 LUMEN INCANDESCENT PG&E CO. OWNED			WOOD POLES 175 WATT MERCURY-VAPOR PG&E CO. OWNED			WOOD POLES 175 WATT MERCURY-VAPOR CITY-OWNED			STEEL POLES 175 WATT MERCURY VAPOR CITY-OWNED			NOTES
LUMENS OUTPUT	4000			7500			7500			7500			(#1) Includes 18% line loss.
RATE SCHEDULE	1			1			14a			14a			(#2) $.01345 per KWH credit to
RATE PER NIGHT	.090			(#9) .090			.037			.037			Hetch Hetchy. See appendix B.
													(#3) $.006421 per KWH for delivery of
ANNUAL PAYMENT TO PG&E CO.		32.85			32.85			13.50			13.50		energy paid to PG&E. see appendix B.
													(#4) 16000 hour rated life. Relamp at
WATTS	220			205			205			205			1200 hours (3yr.), price from
ANNUAL KWH	(#1) 1013			840			840			840			current contract.
													(#5) Based on previous years contract.
ENERGY CREDIT TO CITY BY PG&E CO. (#2)		13.62			11.30			11.30			11.30		(#6) Includes planning, construction
PAYMENT TO PG&E CO. FOR WHEELING (#3)		6.50			5.40			5.40			5.40		and inspection.
TOTAL NET PAYMENT TO PG&E CO.			25.73			26.95			7.60			7.60	(#7) 3½% interest for 15 years averaged
BURN-OUTS, BROKEN GLASS								.40			.40		over 30 year life.
ANNUAL RE-LAMPING (#4)		—			--			4.00			4.00		(#8) See appendix B-4
ANNUAL MAINTENANCE (#5)		—			—			3.00			3.00		(#9) Not in rate schedule. Quoted by
PAYMENT TO MAINTENACE CONTR.		—			—				7.40			7.40	PG&E Co. 1-25-63.
													(#10) Assume administration and
ANNUAL COST			25.73			26.95			14.60			14.60	supervision now in employ of PG&E Co.
													would be required if city performed
UNIT CAPITAL INVESTMENT BY CITY (#6)			—			—	200			385			work. Prorated in direct proportion
AVERAGE COST OF INVESTMENT (30yr) (#7)			—			—		9.00	9.00		16.70	16.70	that overhead districts are to
													total PG&E streetlights
AVERAGE TAXES (30yr.) (#8)		1.70				3.75			—			—	$\frac{13339}{18288} = .73$
													.73 supervisor at 6000(partial) 4380
ADMINISTRATION (#10)									1.25			1.25	.73 clerk at 6000 4380
													.73 gen. foreman at 11000 8000
NET ANNUAL COST (CONTRACTUAL)			24.03			23.20			24.85			32.55	$16760
HETCH HETCHY COST (#11)			7.12			5.90			5.90			5.90	$\frac{16760}{13339} = \$1.25$ per streetlight
													(#11) Energy Credit Less Wheeling
													Costs
TOTAL ANNUAL COST (NET)			31.15			29.10			31.15			38.85	

AET 3-4-63

LUMENS OUTPUT

RATE SCHEDULE

RATE PER NIGHT

ANNUAL PAYMENT TO PG&E CO.

WATTS

ANNUAL KWH

ENERGY CREDIT TO CITY BY PG&E CO

PAYMENT TO PG&E CO. FOR WHEELING

TOTAL NET PAYMENT TO PG&E CO.

BURN-OUTS, BROKEN GLASS
ANNUAL RELAMPING

ANNUAL MAINTENANCE

PAYMENT TO MAINTENANCE CONTR.

ANNUAL COST

UNIT CAPITAL INVEST BY CITY

AVERAGE COST OF INVESTMENT

AVERAGE TAXES

ADMINISTRATION

NET ANNUAL COST (CONTRACTUAL)

HETCH HETCHY COST

TOTAL ANNUAL COST (NET)

AET 3-4-63

TABLE IV

COMPARISON OF COSTS OF STREETLIGHTING IN OVERHEAD DISTRICTS

	WOOD POLES						STEEL POLES-OVERHEAD SERVICE					
	175 Watt		250 Watt		400 Watt							
	PG&E	City	PG&E	City	PG&E	City	City	City	City			
LUMENS OUTPUT	7500	7500	11500	11500	21000	21000	7500	11000	21000			
RATE SCHEDULE	1	14a	1	14a	1	14a	14a	14a	14a			
RATE PER NIGHT	.090	.037	.157	.051	.190	.076	.037	.051	.076			
ANNUAL PAYMENT TO PG&E CO.	32.85	13.50	57.20	18.60	69.50	27.70	13.50	18.60	27.70			
WATTS	205	205	290	290	457	457	205	290	457			
ANNUAL KWH	840	840	1190	1190	1870	1870	840	1190	1870			
ENERGY CREDIT TO CITY BY PG&E CO.	11.30	11.30	16.00	16.00	25.20	25.20	11.30	16.00	25.20			
PAYMENT TO PG&E CO. FOR WHEELING	5.40	5.40	7.65	7.65	12.00	12.00	5.40	7.65	12.00			
TOTAL NET PAYMENT TO PG&E CO.	26.95	7.60	48.85	10.25	56.30	14.50	7.60	10.25	14.50			
BURN-OUTS, BROKEN GLASS		.40		.49		.56	.40	.49	.56			
ANNUAL RELAMPING	—	4.00	—	4.90	—	5.60	4.00	4.90	5.60			
ANNUAL MAINTENANCE	—	3.00	—	3.00	—	3.00	3.00	3.00	3.00	Total Annual Costs on 15 year Amortization Basis		
PAYMENT TO MAINTENANCE CONTR.	—	7.40	—	8.39	—	9.16	7.40	8.39	9.16	7500L	11500L	21000L
ANNUAL COST	26.95	15.00	48.85	18.64	56.30	23.66	15.00	18.64	23.66	15.00	18.64	23.66
UNIT CAPITAL INVEST BY CITY	—	200	—	205	—	220	385	390	405	385	390	405
AVERAGE COST OF INVESTMENT	—	9.00	—	9.30	—	10.00	16.80	17.00	17.60	33.60	34.00	35.20
AVERAGE TAXES	3.75		3.85		4.13							
ADMINISTRATION		1.25		1.25		1.25	1.25	1.25	1.25	1.25	1.25	1.25
NET ANNUAL COST (CONTRACTUAL)	23.20	25.25	45.00	29.19	52.17	34.91	33.05	36.89	42.51	49.85	53.89	60.11
HETCH HETCHY COST	5.90	5.90	8.35	8.35	13.20	13.20	5.90	8.35	13.20	5.90	8.35	13.20
TOTAL ANNUAL COST (NET)	29.10	31.15	53.35	37.54	65.37	48.11	38.95	45.24	55.71	55.75	62.24	73.31

NOTES:

All notes shown on Table III apply to Table IV

This solution to the problem, which has been used successfully in Oakland, might be used in secondary business districts or major thoroughfares. In these applications, it is likely that 400-watt mercury-vapor units would be used. The long term costs per streetlight are as follows:

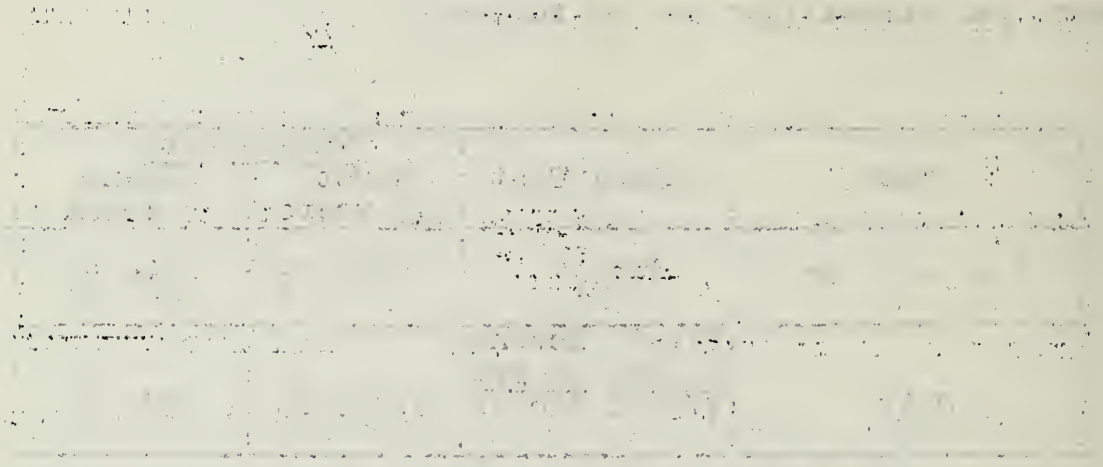
Owner	Annual Cost	Total Costs	
		First 15 years	Second 15 years
P.G. & E. Co.	$65.37	$980.55	$980.55
City	First 15 yrs $73.31 Second 15 yrs $38.11	$1099.65	$571.65

Obviously, the savings due to City ownership are considerable when viewed in the long term. The costs for the first 15 years are close enough that improved engineering could make them equal or even to the City's advantage. The savings in the second 15 years is almost enough to pay for two streetlights.

B. Underground Districts

As pointed out, about 54% of our existing street lights are in underground districts which total only about 18% of our streets. Most of the underground districts are in the downtown areas where a high level of illumination is desirable. This, of course, accounts for the fact that the ratio of street lights to street mileage is higher than in the overhead districts.

However, with modern streetlights, a reduction in the number of electroliers per block is possible in many cases and at



the same time, an improvement in the quality and intensity of of lighting can be achieved. As many as eight poles per block have been used where four modern units would be sufficient.

The engineering problem of how to light the streets is easy to solve by applying the Recommended Practice. However, the important problem is to determine the most economical way good lighting can be accomplished. As identical systems can be installed by the Pacific Gas and Electric Company or the City, the comparison of cost is the significant question.

Consequently, the costs of identical streetlights for Pacific Gas and Electric Company and City ownership will be compared and then these will be compared with the costs of the existing systems.

The price bid for furnishing streetlighting service of a particular kind depends greatly on the quantity. This was borne out in the earlier discussion of systems in overhead districts where the Pacific Gas and Electric Company was able to reduce its rates on the basis that some 15,000 units were involved. It is possible, too, that the opposite situation could exist and the prices bid could go higher after the Company gained experience with certain systems. This condition is revealed in the price trends shown in Table V.

TABLE V

Unit Costs of P.G. & E.-Owned Street Lighting

Year	6000 Lumen Incandescent Quan.	6000 Lumen Incandescent Cost/Night	400-Watt Mercury-Vapor Quan.	400-Watt Mercury-Vapor Cost/Night	23000 Lumen Fluorescent Quan.	23000 Lumen Fluorescent Cost/Night
1941	236	$.131	----	----	----	----
1957	260	.151	None	$.263	None	$.301
1958	260	.151	None	.263	50	.301
1960	270	.151	None	.263	41	.583
1961	281	.151	1	.263	41	.583
1962	281	.151	1	.263	41	.583

The prices and quantities shown were taken from Schedules 4 and 5 of the Contract with the Pacific Gas and Electric Company and are for standard electroliers furnished and maintained by the Company with energy supplied through underground service. From the trend, it is obvious that experience contributed heavily to the price increase for the fluorescent units.

These prices were discussed with the Pacific Gas and Elec- Electric Company. The actual cost of converting an obsolete lighting system to a modern one depends to a great extent on how much of the existing conduit can be re-used. Thus, the Pacific Gas and Electric Company was reluctant to quote rates for a proposed improved system without more exact knowledge of the problems. However, after consideration, they agreed that while piecemeal improvements could be made under the existing rate schedules, considerable revision of the prices may well be necessary in the

event of a large scale streetlighting improvement program. The Company estimated that the costs of streetlights in underground districts would be as shown in Table VI. The existing rates are shown for comparison.

TABLE VI

Costs of P.G. & E.-Owned Street Lights
In Underground Districts

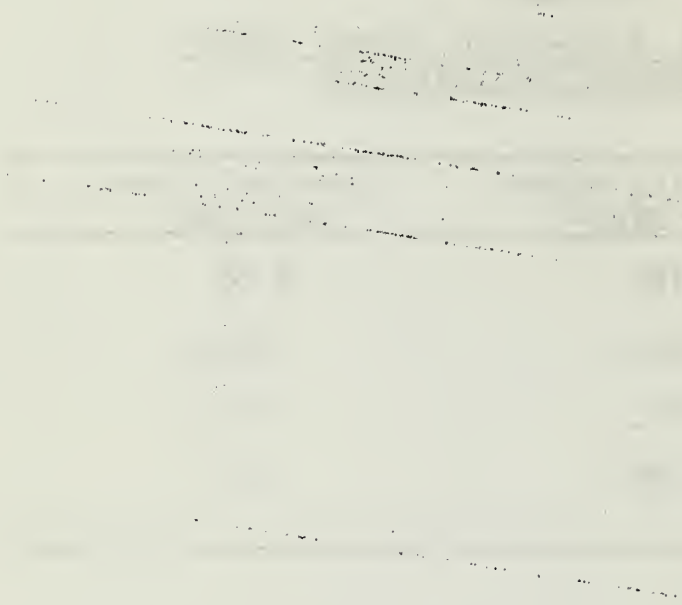
Rating	Existing Rates Per Night	Proposed Rates Per Night
175 watt	$.187	$.38
250 watt	.230	.405
400 watt	.263	.435
700 watt	.388	.55

Based on the available information, Table VII was compiled to show the difference in cost between City and Pacific Gas and Electric Company ownership of streetlights.

Over a 30-year period, City ownership is advantageous for all types of streetlights in underground districts.

C. Comparison of Annual Costs

It is of interest to compare the costs of existing systems and the proposed systems for both City and Company ownership. Since we are interested in the net cost to the City, such items



	AET 4-1-63 Rev.
OWNER	
RATE SCHEDULE	
RATE PER NIGHT	quoted by PG&E Co.
ANNUAL BUDGET RATI	
WATTS	
ANNUAL KWH	
ENERGY CREDIT	tch Hetchy
WHEELING	o.
NET PAYMENT TO PG	eeling
BURN-OUTS, BROK	
ANNUAL RELAMP COS	
ANNUAL MAINT. COS	
TOTAL MAINT. & OP	nance Contractor
ANNUAL COST	ment for streetlight
UNIT INVESTMENT	
ANNUAL INVESTMENT	e
TAXES PAID BY PG&	e
NET ANNUAL COST (C	e
HETCH HETCHY CO	
TOTAL ANNUAL CO	

AET 4-1-63 Rev.

TABLE VII

COMPARISON OF COSTS OF STREETLIGHTING IN UNDERGROUND DISTRICTS
ELECTROLIER SYSTEMS - STEEL STANDARDS

OWNER	175 Watt		250 Watt		400 Watt		700 Watt		1000 Watt		
	PG&E	City	PG&E	City	PG&E	City	PG&E	City	PG&E	City	
RATE SCHEDULE	4	15	4	15	4	15	4	15	4	15	
RATE PER NIGHT	.38	—	.405	—	.435	—	.55	—	—	—	Revised rates quoted by PG&E Co.
ANNUAL BUDGET RATE	138.70	—	147.83	—	158.78	—	200.75	—	—	—	
WATTS	205	205	290	290	457	457	753	753	1120	1120	
ANNUAL KWH	840	840	1190	1190	1870	1870	3100	3100	4600	4600	
ENERGY CREDIT	11.30	—	16.00	—	25.20	—	41.80	—	62.00	—	Returned to Hetch Hetchy
WHEELING	5.40	5.40	7.65	7.65	12.00	12.00	20.00	20.00	29.50	29.50	Paid to PG&E Co.
NET PAYMENT TO PG&E CO.	132.80	5.40	139.48	7.65	145.58	12.00	179.95	20.00	—	29.50	Includes wheeling
BURN-OUTS, BROKEN GLASS		.40		.49		.56		1.20		1.20	
ANNUAL RELAMP COST	—	4.00	—	4.90	—	5.55	—	12.00	—	12.00	
ANNUAL MAINT. COST	—	2.90	—	2.90	—	2.90	—	2.90	—	2.90	
TOTAL MAINT. & OPERATIONS	—	7.30	—	8.29	—	9.01	—	16.10	—	16.10	Paid to Maintenance Contractor
ANNUAL COST	132.80	12.70	139.48	15.94	145.58	21.01	179.95	36.10	—	45.60	Total Cash payment for streetlight
UNIT INVESTMENT	—	924.	—	930.	—	945.	—	1024.	—	1040.	
ANNUAL INVESTMENT COST	—	40.	—	40.25	—	41.00	—	44.50	—	45.00	30 year average
TAXES PAID BY PG&E	15.80	—	15.90	—	16.10	—	17.10	—	17.80	—	30 year average
NET ANNUAL COST (CONTRACTUAL)	117.00	52.70	123.58	56.19	129.48	62.01	162.85	80.60	—	90.60	30 year average
HETCH HETCHY COST	5.90	5.90	8.35	8.35	13.20	13.20	21.80	21.80		32.50	
TOTAL ANNUAL COST (NET)	122.90	58.60	141.93	64.54	142.68	75.21	184.65	102.40		123.10	

AET 2-11-63

Owner	
Rate Schedule	
Rate per Night	
Annual Budget Rate	
Watts	
Annual KWH	
Energy Credit	
Wheeling	
Net Payment PG&E	
Burn-Outs, Broken Glass	
Annual Re-Lamping	
Annual Maint.	
Total Annual M & O	
Annual Cost	
Unit Investment	
Annual Inv. Cost 30 yr.	
Taxes Paid	1
Paid to Muni. Railway	
Net Annual Cost (Contractual)	
Hetch Hetchy Cost	
Total Net Annual Cost	

AET 2-11-63

TABLE VIIa

TROLLEY POLE SYSTEMS - UNDERGROUND SERVICE

Owner	175 Watt		250 Watt		400 Watt		700 Watt		1000 Watt	
	PG&E	City	PG&E	City	PG&E	City	PG&E	City	PG&E	City
Rate Schedule	3	15	3	15	3	15	3	15	—	15
Rate per Night	.182	—	.225	—	.258	—	.383	—	.462	—
Annual Budget Rate	66.50	—	82.00	—	94.50	3	140.00	—	169.00	—
Watts	205		290		457		753		1120	
Annual KWH	840		1190		1870		3100		4600	
Energy Credit	11.30	—	16.00	3	25.20	—	41.80	—	62.00	—
Wheeling	5.40	5.40	7.65	7.65	12.00	12.00	20.00	20.00	29.50	29.50
Net Payment PG&E	60.60	5.40	73.65	7.65	81.30	12.00	118.20	20.00	136.50	29.50
Burn-Outs, Broken Glass		.40		.49		.56		1.20		1.20
Annual Re-Lamping	—	4.00	—	4.90	—	5.55	—	12.00	—	12.00
Annual Maint.	—	1.90	—	1.90	—	1.90	—	1.90	—	1.90
Total Annual M & O	—	6.30	—	7.29	—	8.01	—	15.10	—	15.10
Annual Cost	60.60	11.70	73.65	14.94	81.30	20.01	118.20	35.10	136.50	44.60
Unit Investment	—	767.	—	773.	—	788.	—	844.	—	851.
Annual Inv. Cost 30 yr.	—	33.00	—	33.50	—	34.00	—	36.50	—	37.00
Taxes Paid	13.70	—	13.80	—	14.00	—	14.50	—	15.20	—
Paid to Muni. Railway	1.50	—	2.25	—	3.50	—	3.50	—	3.50	—
Net Annual Cost (Contractual)	45.40	44.70	57.60	48.44	63.80	54.01	100.20	71.60	117.80	81.60
Hetch Hetchy Cost	5.90	5.90	8.35	8.35	13.20	13.20	21.80	21.80	32.50	32.50
Total Net Annual Cost	51.30	50.60	65.95	56.75	77.00	67.21	122.00	93.40	150.30	114.10

as taxes, cost of delivery of Hetch Hetchy energy and maintenance must be included in the analysis. Furthermore, the new systems usually use fewer poles than many of those existing. Thus the cost comparison must be based on the complete system or at least a one-block section rather than the difference in the cost of individual units.

For example, there is an existing system owned by the Pacific Gas and Electric Company on California Street between Kearny Street and Van Ness Avenue. This system which consists of 16-foot post top luminaires with 4000 lumen lamps at an average spacing of 107 feet was installed in 1927 and 1930.

The proposed system for California Street would consist of 400 watt mercury vapor units on steel poles 30 feet high and spaced about 137 feet. Such a system would provide about 1.2 footcandles maintained average illumination in accordance with the IES-ASA Recommendations. This system could be owned by either the City or the Pacific Gas and Electric Company. The comparative costs are shown in Table VIII.

TABLE VIII

Cost Comparison
California Street System - Kearny Street to Van Ness Avenue

Owner	System	Average Footcandles	Average Annual Operating Cost
P.G. & E. Co.	Existing 4000 lumen incandescent	.07	$1,993.00
P.G. & E. Co.	Proposed 400-watt mercury-vapor	1.2	$4,224.00
City	Proposed 400-watt mercury-vapor	1.2	$1,505.00

The savings in annual cost due to City ownership are obviously important. However, considerable money must be invested to realize the saving. The magnitude of such investment will be shown later.

Another example is that of the system on Broadway between Battery and Powell Streets. This system also consists of 16-foot upright electroliers installed in 1938 but has the added distinction of having City-owned conduits and foundations. It also should be replaced with 400-watt mercury-vapor luminaires on steel poles.

The costs are shown in Table IX.

TABLE IX

Cost Comparison
Broadway System - Battery Street to Powell Street

Owner	System	Average Footcandles	Annual Operating Cost
P.G. & E. Co.	Existing 4000 lumen incandescent	.07	$1,830.00
P.G. & E. Co.	Proposed 400-watt mercury-vapor	1.2	$2,323.00
City	Proposed 400-watt mercury-vapor	1.2	$ 821.00

Again, the magnitude of the savings is apparent. The annual cost of a new City-owned system is only about 1/3 that of the completely inadequate system it would replace.

The "Downtown Triangle System" offers another example of a system where savings are possible. This system, which is owned by the Pacific Gas and Electric Company, consists of twin 10,000 lumen incandescent units on ornamental standards. The standards were installed in 1918. One lamp in each standard burns all night. The other is extinguished at midnight. Much discussion has taken place about this system in past years, and attempts have been made from time to time to improve it. Thus mercury-vapor units were installed around Union Square and more recently, fluorescent units were installed on Geary Street between Mason Street and Van Ness Avenue. It is interesting to compare the existing system, the fluorescent systems and a proposed system in performance and annual cost as shown in Table X.

TABLE X

Cost Comparison
Downtown Triangle and Geary Street Systems

Owner	System	Average Footcandles	Annual * Cost Per Block
P.G. & E. Co.	Existing 2-10,000 lumen incandescent 8 per block	.14	$1,079.00
P.G. & E. Co.	Existing 23,000 lumen fluorescent 5 per block	.70	$1,064.00
P.G. & E. Co.	Proposed 700 w. mercury 4 per block	1.90	$ 556.00
City	Proposed 700 w. mercury 4 per block	1.90	$ 232.80

*Annual cost includes payments to P. G. & E. Co. and for maintenance by Contractor.

Here again, the advantages of City ownership are apparent. A new high level system, whether owned by the Pacific Gas and Electric Company or the City, actually would cost less than the existing system.

A last example of the relative costs of streetlighting systems owned by the City and the Pacific Gas and Electric Company is of interest since it represents the cheapest installation possible in the underground districts. This system was installed on Mission Street between 15th Street and Precita Avenue by the Pacific Gas and Electric Company. It consists of 124 - 400-watt mercury-vapor luminaires installed on trolley poles owned by the Municipal Railway. The comparative annual costs of this and an identical system owned by the City are shown in Table XI.

TABLE XI

Cost Comparison
Mission Street System Between 15th Street and Precita Avenue

Owner	Annual Rate Per Luminaire	Annual Cost of System
P.G. & E. Co.	$77.00	$9,548.00
City	$32.65	$4,048.00
	Annual Saving	$5,500.00

If all things were constant, the annual savings would amount to $165,000 during the 30-year estimated life of this system. The estimated cost of installation is $93,000.00.

The examples listed show significant savings, to the City through Municipal ownership of the streetlighting systems even under the existing rates. It is probable that the advocates of City ownership cited in Section III based their opinions on similar analyses. The savings are much greater when the proposed rates are applied as shown in Sec. V. However, investment costs must be considered and any tax loss suffered must be included in the total cost of a streetlighting system. Since the investment costs are dependent on the methods of financing, their discussion is included in a later section after the extent of the total work is determined.

Much of the existing streetlighting is inadequate and must be replaced. It is necessary, therefore,to determine the improvements needed before any cost estimates can be made.

V

RECOMMENDATIONS FOR IMPROVEMENT OF THE STREETLIGHTING SYSTEM

V. Recommendations for the Improvement of the Streetlighting Systems

As recommended in Section II, the streetlighting should be based on street use rather than on the accident of having overhead or underground wiring. However, utility pole spacing was not designed with streetlighting in mind. Consequently, the discussion must be separated again into Overhead and Underground districts.

A. Overhead Districts

As stated, utility pole spacings were arranged for convenient power distribution rather than streetlighting. Compromises must be made in streetlighting arrangements to avoid an excessive number of poles. The problem is best illustrated by consideration of the problem of improving the lighting on some typical streets.

A block on Thirty-second Avenue between Kirkham and Lawton Streets and a block on Bartlett Street between Twenty-fourth and Twenty-fifth Streets were taken at random as samples of the situation in overhead districts. Sketches SEL-2313 and SEL-2314 show the approximate existing pole locations and the proposed streetlighting systems.

Thirty-second Avenue and Bartlett Streets are classified in Categories G (0.2 - 0.3 footcandles) and F (0.3 to 0.4 footcandles), respectively.

Examination of the sketches and the tabulated data shows that the recommendations of the IES-ASA are fulfilled by the

FORM NO. 11794

D

POLE

KIRKHA

BE REMOVED

VAPOR LUMINAIRE

TION DATA

200'

NTAINED) .295 FT. C.

ER LUMINAIRE) .82 FT. C.

.12 FT. C.

600'

= 2.5

WITHIN LIMITS
SA FOR LIGHT
REET CATEGORY G.

LAWTON

OF SAN FRANCISCO
S - BUREAU OF ENGINEERING

REFERENCES

TION FOR TYPICAL
LICT BLOCK

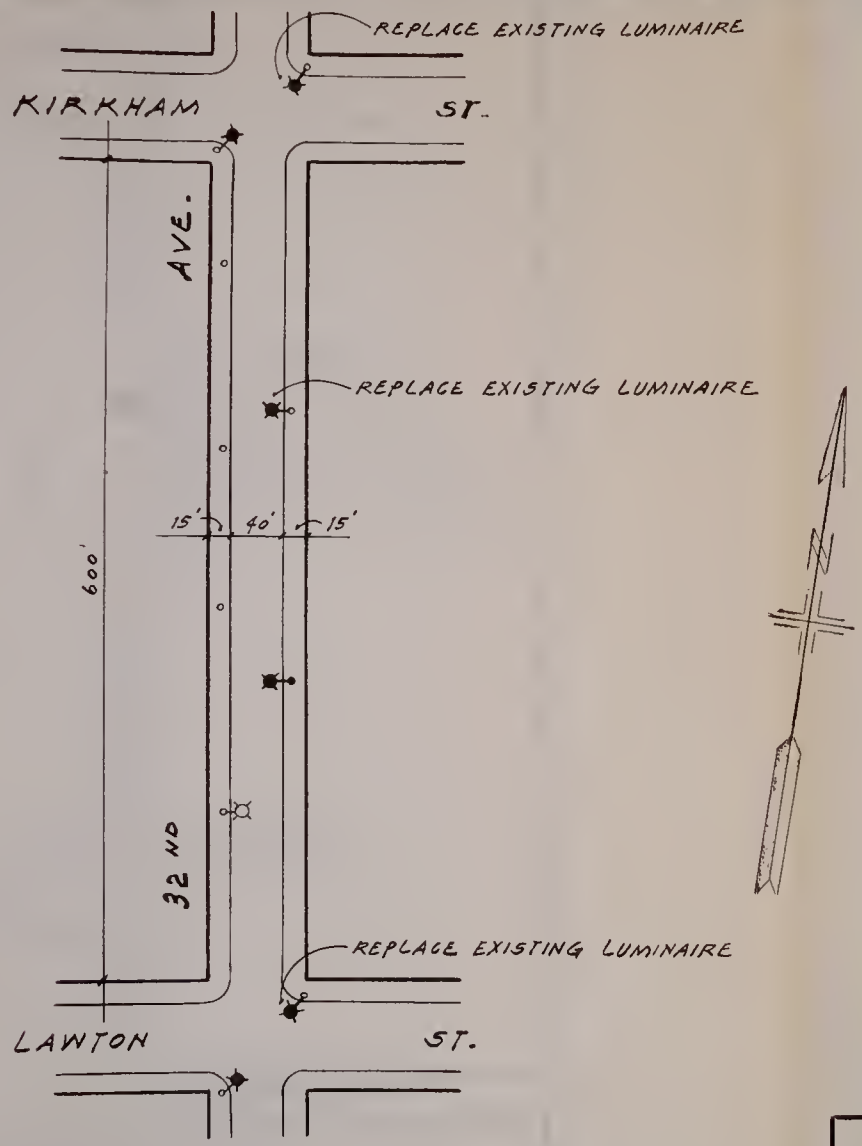
E: 1" = 100'
ET
SHEETS

FILE

CHANGE

SEL - 2313

FORM NO. 11784



LEGEND

- ○ EXISTING WOOD UTILITY POLE
- ● NEW WOOD POLE
- ⌑ EXISTING LUMINAIRE TO BE REMOVED
- ■ NEW 175 WATT MERCURY VAPOR LUMINAIRE

ILLUMINATION DATA

AVERAGE SPACING	200'
AVERAGE ILLUMINATION (MAINTAINED)	.295 FT. C.
MAXIMUM ILLUMINATION (UNDER LUMINAIRE)	.82 FT. C.
MINIMUM ILLUMINATION	.12 FT. C.

RATIO $\frac{\text{AVERAGE}}{\text{MINIMUM}} = \frac{.295}{.12} = 2.5$

NOTE:

ILLUMINATION DATA ARE WITHIN LIMITS PRESCRIBED BY IES - ASA FOR LIGHT TRAFFIC. PROPOSED STREET CATEGORY G.

REFERENCES	NO.	DATE	DESCRIPTION	BY

TABLE OF CHANGES
CAUTION: CHECK WITH TRACING TO SEE IF YOU HAVE LATEST REVISION

	BY	DATE
DR.	H.B.	8-63
TR.		
CK.	AGT	863
APP.	AGT	862
APP.	G.G.	8/17/63

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS - BUREAU OF ENGINEERING

PROPOSED ILLUMINATION FOR TYPICAL SUNSET DISTRICT BLOCK

APPROVED [signature] DATE 8-18-63 CITY ENGINEER

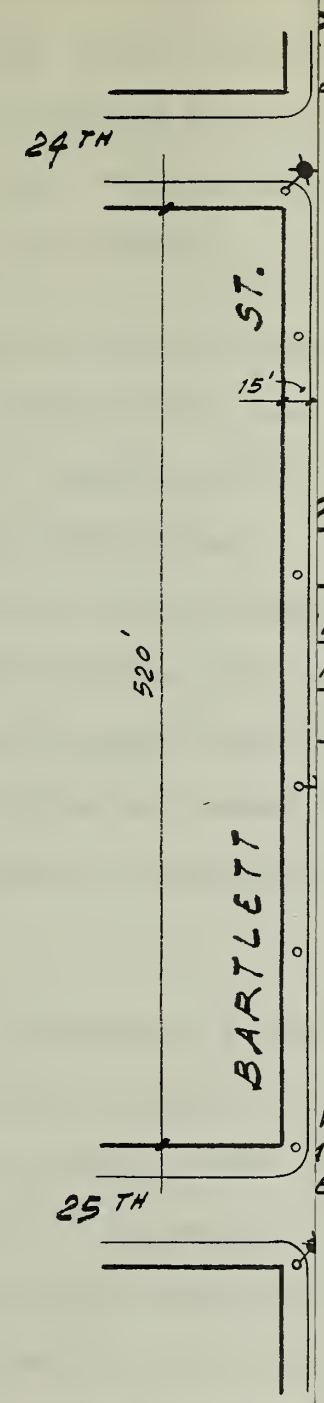
SCALE: 1" = 100'
SHEET OF SHEETS

FILE

CHANGE

SEL - 2313

FORM NO. 11794



ON DATA

173'

TAINED) .39 FT. C.

R LUMINAIRE) .82 FT. C.

.15 FT. C.

2.6

WITHIN LIMITS
1 FOR LIGHT
ET CATEGORY F.

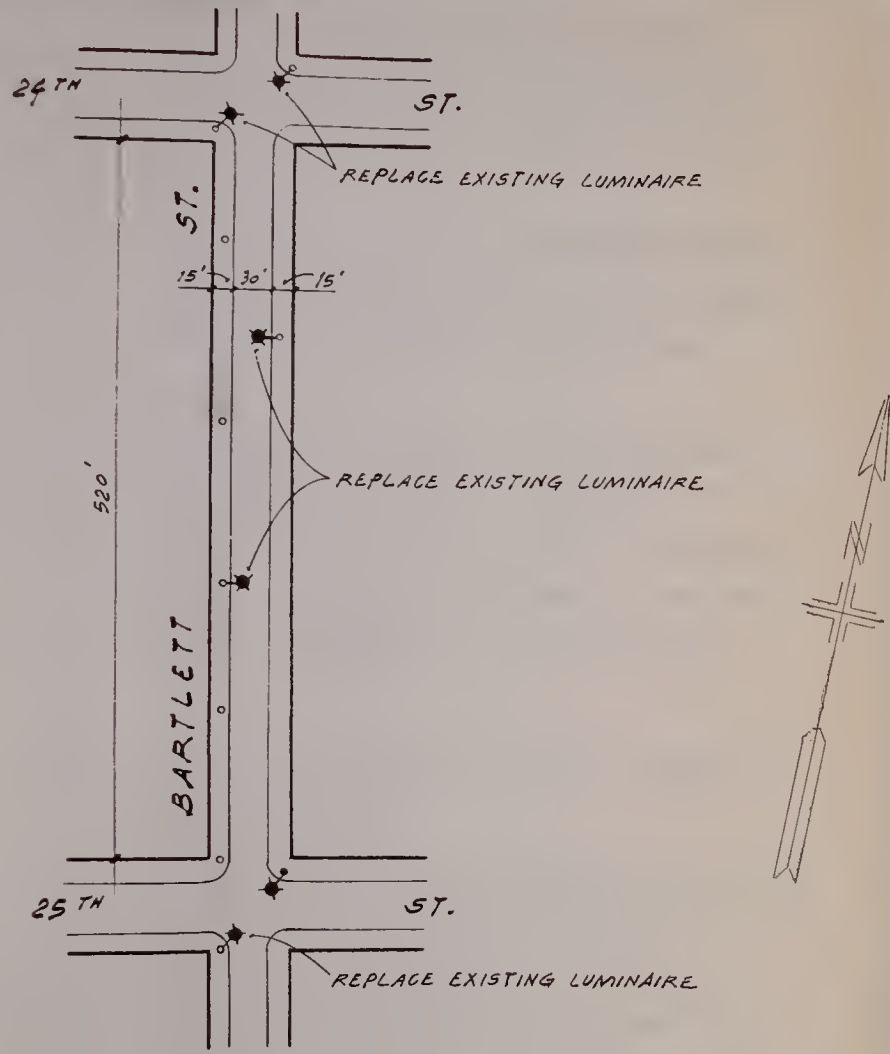
SAN FRANCISCO
- BUREAU OF ENGINEERING

ON FOR TYPICAL
CT BLOCK

REFERENCES	1" = 100' SHEETS	FILE	CHANGE

SEL - 2314

FORM NO. 11784



LEGEND

- ○ EXISTING WOOD UTILITY POLE
- • NEW WOOD POLE
- ✱ NEW 175 WATT MERCURY VAPOR LUMINAIRE

ILLUMINATION DATA

AVERAGE SPACING	173'
AVERAGE ILLUMINATION (MAINTAINED)	.39 FT. C.
MAXIMUM ILLUMINATION (UNDER LUMINAIRE)	.82 FT. C.
MINIMUM ILLUMINATION	.15 FT. C.

RATIO $\frac{\text{AVERAGE}}{\text{MINIMUM}} = \frac{.39}{.15} = 2.6$

NOTE:

ILLUMINATION DATA ARE WITHIN LIMITS PRESCRIBED BY IES-ASA FOR LIGHT TRAFFIC. PROPOSED STREET CATEGORY F.

REFERENCES

NO.	DATE	DESCRIPTION	BY

TABLE OF CHANGES
CAUTION: CHECK WITH TRACING TO SEE IF YOU HAVE LATEST REVISION

	BY	DATE
DR.	H.S.	8-63
TR.		
CK.	AGT	863
APP.	AGT	863
APP.	G.C.	5/19/63

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS - BUREAU OF ENGINEERING

PROPOSED ILLUMINATION FOR TYPICAL MISSION DISTRICT BLOCK

APPROVED Clifford J. Leonard
DATE 9-18-63 CITY ENGINEER

SCALE: 1" = 100'
SHEET OF SHEETS

FILE

CHANGE

SEL - 2314

expedient of replacing the existing 4000 lumen incandescent luminaires with 175-watt mercury-vapor luminaires and making some adjustment in the spacing. In both cases, an additional luminaire is included at the intersections. This fulfills the requirement that the intersections be better illuminated than the remainder of the street.

Vast areas of the City including the Sunset, Parkside, Richmond and Mission Districts should be lighted approximately as shown on the sketches. Spacings will vary, of course, but should not exceed the 200 feet shown.

As pointed out in Section III (Cost of Streetlighting) the low cost quoted by the Pacific Gas & Electric Company of the 175-watt mercury-vapor unit was based on an estimated 15,000 units. This is the estimated number of streetlights needed to improve the illumination in residential districts to the recommended levels.

As no additional funds are required to make this improvement, it should be started immediately.

Those streets in the overhead districts requiring more than minimum levels of illumination present a different problem. Table IV shows that considerable savings are possible with City-ownership of the 250 and 400-watt streetlights. This saving is possible even when the units are installed on streetlight standards rather than on the utility company's wooden poles.

Consequently, those streets in overhead districts that fall into Categories B through D should be illuminated with 250-watt

or 400-watt luminaires, as required, mounted on separate street-lighting standards supplied by overhead service.

B. Underground Districts

The streetlighting systems in the underground districts fall into three classes:

1. Systems that are physically deteriorated and should be replaced for this reason as well as for improvement of the illumination.
2. Systems that are in fair physical condition but have an excessive number of standards and could be replaced with systems giving better illumination with fewer poles and less cost.
3. Systems installed in recent years that need not be changed.

An inventory of all underground systems was made. The results are tabulated on Work Sheets filed in the Office of the City Engineer which show the existing system as well as its suggested replacement.

Note that the streets have been placed in Categories based on traffic density and street use. The proposed systems will provide levels of illumination in accordance with the recommendations of Section II.

C. Priorities for Improvement

The improvement of streetlighting is a City-wide project. With the exception of a relatively few streets, the lighting should be improved throughout the City. Since the improvement cannot be accomplished immediately, there is a problem in establishing priorities for the work.

Police Department and traffic records contain information of value in establishing a priority list. Of course, such information varies with time as neighborhood and street use patterns change. For example, last year's statistics for the Western Addition or the old Produce Area are of little value in determining work to be done in a redevelopment area. Consequently such statistics must be used carefully in connection with expected trends in population and traffic.

Some of the vavailable statistics compiled on a City-wide basis are summarized in Table XII.

TABLE XII

City-wide Crime and Traffic Accidents Summary

Activity		Period	Day	Night
Street crime -	Aggravated Assault	1962	168	439
	Purse Snatching	1962	76	145
	Robbery	1962	163	494
Traffic Accidents -	Pedestrian	1958	1,024	423
	Vehicle	1958	10,948	7,052

This illustrates the dual function of improved lighting. First, light is a deterrent to crime and provides citizens with a sense of security. Secondly, it is a traffic aid. Motorists and pedestrians alike benefit from the visibility provided by adequate streetlighting.

The statistics are more striking when it is considered that streets are used much less at night. It is estimated that only 25 percent of the vehicular traffic moves at night.

In the establishment of priorities for the improvement of streetlighting, the following factors must be considered.

1. Traffic
    a. Pedestrian Accident Statistics
    b. Vehicular Accident Statistics
    c. Complaints

2. Street Crime
    a. Records and Statistics
    b. Potential based on Police Reports and complaints

3. Public Transportation
    a. Bus Stops and Waiting Areas

4. Business
    a. Night Shopping
    b. Entertainment Areas
    c. Security

5. Complaints

   a. Nuisance and Vandalism

   b. Other than reported in 1 and 2 above.

Maps are being prepared on which the above information will be shown. It is possible that the best way to keep these records will be on punched-cards from which the data can be analyzed in several ways. For example, a location included under all five of the items listed above would certainly have a high priority in regard to improved streetlighting. In all cases, the effectiveness of the existing streetlighting must be assessed. It is not reasonable to expect crime and accidents to be reduced below daytime rates.

In general, the priorities will be assigned as follows:

Priority 1 - Locations proved dangerous from a traffic and crime standpoint.

Priority 2 - Locations where the lighting is below recommended levels but not high on crime or accident reports.

Priority 3 - Locations where there is an economic advantage in replacing obsolete systems with less expensive modern systems.

It is of considerable interest that most complaints originate in the overhead districts. Improvement of the lighting in these areas can be accomplished without capital investment and should be started as soon as possible.

A program has been started to improve the lighting at locations having records of high nighttime traffic accident rates. This program is being financed by gasoline tax funds and should continue independent of the other aspects of the survey.

VI

ESTIMATE OF THE COST OF REHABILITATION OF OLD CITY EQUIPMENT AND REPLACEMENT OF OBSOLETE PACIFIC GAS AND ELECTRIC CO. SYSTEM

VI. Estimate of the Cost of Rehabilitation of Old City Equipment and Replacement of Obsolete Pacific Gas and Electric Co. Systems

Streetlighting costs were discussed in Section III and the conclusion reached that City-ownership was advantageous in all cases but one. It was shown that Utility Company ownership is to the City's advantage in the lowest categories of street use. In all cases, it was shown (Tables VII and VIIa) that the cost of the investment was higher than the total annual operating cost.

If the City now owned its streetlighting systems, there would be a considerable annual saving in cost.

The purpose of this Section is to determine the following costs:

a. Annual cost of a completely modernized system.

b. Investment required to obtain the modern system.

Since the modern system can be obtained with either City or Utility Company ownership, the relative annual costs will be determined. In addition, the investment required by the City for a modern system will be estimated. Finally, the annual costs of the existing system will be compared with those of the proposed system.

Again, for purposes of analysis, it is desirable to separate the overhead and underground districts.

A. Overhead Districts

In Section III(A), it was concluded that for most residential areas, a new rate proposed by the Pacific Gas and

Electric Company for the 175-watt mercury-vapor streetlight is to the City's advantage. However, the advantage disappeared in the case of the larger lamps. It was shown that it is actually cheaper to install separate poles with streetlights on business streets or major thoroughfares than it is to have the Utility Company provide streetlights on its own poles.

The overhead districts include approximately 14 miles of secondary business streets, such as San Bruno Avenue and major thoroughfares, such as Fulton Street. About seven miles of streets in overhead districts have trolley poles which provide the cheapest kind of support for streetlights. The costs of streetlighting in overhead districts are summarized in Table XIII.

TABLE XIII

Costs of Street Lighting in Overhead Districts

Category	C & D	D & F	G
Luminaire	400W	250W	175W
Owner	City	City	P.G. & E.
Rate/Night	$.076	$.051	$.09
Quantity	300	150	15,000
Total Annual Rate for Budget	$8,322.00	$2,795.00	$492,750.00
Watts	457	290	205
Annual KWH/Unit	1870	1190	840
Total Annual KWH	561,000	179,000	12,600,000
Total Energy Credit (Hetch Hetchy)	$7,600.00	$2,400.00	$170,000.00
Total Wheeling(P.G.&E.)	$3,600.00	$1,150.00	$ 81,000.00
Burn Outs,Broken Glass	$.40	$.49	------
Unit Relamping	$4.00	$4.90	------
Unit Maintenance	$2.90	$2.90	------
Total Maint. & Relamp	$7.30	$8.29	------
Total Maintenance Cost	$2,190.00	$1,243.50	------
Total Net Annual Cost	$10,512.00	$5,510.00	$492,750.00
Cost of One Unit (Installation)	$405.00	$390.00	------
Total Investment Cost	$121,500.00	$58,500.00	------

B. Underground Districts

In Section III(B), it was concluded that City-ownership of streetlighting is advantageous to the City in Underground districts. Consequently, a survey was made of the whole underground system. Estimates of the average illumination levels were made and compared with the recommended levels for the various street categories. All of the information was compiled and tabulated on the Work Sheets previously mentioned in Section IVb.

The total quantities of the proposed streetlighting work were estimated where changes were required. Where existing systems were adequate, no change was suggested regardless of ownership. Therefore, the proposed streetlighting system will be composed of both City-owned and Pacific Gas and Electric Company-owned units. This condition will exist until the time that it is necessary to replace the utility-owned systems. At that time, a decision based on costs then in existence, must be made whether or not to replace the system with one ofCity-ownership.

It is significant that most of the streetlighting systems installed since 1948 are either satisfactory or can be modernized at reasonable expense. No systems were installed during the war. Hence it will be usually to the City's advantage to replace utility company systems that were installed prior to 1941. The interval between 1941 and the eventual time of replacement of such systems will be at least 25 years. As any investment costs will, no doubt, have been recovered by the Pacific Gas and Electric Company in that time, the discontinuance of such systems should have no adverse effect on the assets of that Company.

Initial Investment for City-Ownership

As a result of the survey of existing streetlights in underground districts, it is proposed that a total of 7,398 street lights be removed as obsolete and inadequate. In their place, a total of 6,399 new streetlights should be installed.

The type and rating of the new streetlights should be as shown in Table XIV.

The estimated cost of the improvements to the street-lighting systems in the underground districts is approximately $6,300,000.00.

TABLE XIV
Initial Investment and Annual Costs of
Proposed Streetlighting Systems

Type	1(a) Quantity	2(b) Unit Investment	3 Total Investment	4(c) Unit Annual Cost P.G.&E.	4(c) Unit Annual Cost City	5 Total Annual Cost P.G.&E.	5 Total Annual Cost City
175W with Standard	1,831	$1,029	$1,884,099	$122.90	$18.60	$225,030	$34,057
250W with Standard	358	985	352,630	141.93	24.29	50,811	8,696
400W with Standard	2,340	1,000	2,340,000	142.68	34.21	333,871	80,051
2-400W with Standard	133	1,200	159,600	180.00(d)	68.42	23,940	9,100
700W with Standard	668	1,129	754,172	184.65	57.90	123,346	38,677
1000W with Standard	30	1,040	31,200	136.50	78.10	4,095	2,343
250W on Exist. Standard	207	450	93,150	60.60	24.29	12,544	5,028
2-250W on Exist.Standard	16	600	9,600	100.00(d)	48.58	1,600	777
400W on Exist. Standard	499	475	237,025	81.30	34.21	40,569	17,071
2-400W on Exist. Standard	449	675	303,075	110.00(d)	68.42	49,390	30,721
250W on Trolley Pole	24	773	18,552	65.95	23.29	1,583	559
400W on Trolley Pole	51	788	40,188	77.00	33.21	3,927	1,694
700W on Trolley Pole	98	844	82,712	122.00	56.90	11,956	5,576
TOTALS			$6,306,003			$882,662	$234,350

(a) See Work Sheets
(b) See Appendix B-1. Prices averaged to account for concrete standards.
(c) See Table VII and Table VIIa
(d) Estimated

Anticipated Annual Costs of Improved System for City and Pacific Gas and Electric Company Ownership

Considering only the parts of the City's streetlighting system proposed for improvement, it is important to compare the annual operating costs for both City and Company ownership. It is then necessary to apply the annual cost of the investment capital to the City's costs to determine whether or not City-ownership is advantageous.

Table XV shows the costs of the proposed improvements only. Hetch Hetchy energy costs being equal in each case are not included.

TABLE XV

Costs of Improvements to the Streetlighting System

	City Ownership	P.G.& E.Co. Ownership
A. Annual Operating Costs		
Overhead Districts See Table XIII	$ 16,022.00	$492,750.00
Underground Districts See Table XIV	$234,350.00	$882,662.00
Total Annual Operating Cost	$250,372.00	$1,375,412.00
B. Average Annual Cost of* Investment for 15 years	$546,997.00	
Total Average Annual Cost for First 15 years	$797,369.00	$1,375,412.00

*Computed as annual cost of $6,300,000 at 3-1/2% for 15 years.

There is an apparent total annual saving of $578,043.00 in the first 15 years due to City-ownership of the improvements. The saving would amount to $1,125,040.00 per year thereafter.

Comparison of Annual Costs of Existing and Proposed Systems

It is interesting to compare the annual costs of the existing street lighting system with the proposed system. In this analysis, the costs are tabulated in the form used by the Bureau of Light, Heat and Power in its annual report.

The actual number of streetlights in service changes frequently due to street construction, the underground program and the occasional additions to the system on the basis of complaints. For these reasons, the tabulated quantities vary depending on the time that information was gathered. In most instances, the differences are small and are best disregarded.

Before comparing costs, it is important to realize the extent of the work contemplated. This information is tabulated in various parts of the report and is summarized in Table XVI.

TABLE XVI

Contemplated Changes in the Streetlighting System

Districts	Number of Streetlights					
	Existing			Proposed		
	City Owned	(*) P.G.&E. Owned	Total	City Owned	(*) P.G.&E. Owned	Total
Overhead	46	13,327	13,373	496	15,000	15,496
Underground	9,241	6,520	15,761	11,765	3,107	14,872
Total	9,287	19,847	29,134	12,261	18,107	30,368

(*) Includes jointly owned systems.

Note that the total number of streetlights will increase from 29,134 to 30,368. However, the more significant changes are the increase of over 2000 units proposed for the overhead districts and a decrease of almost 900 units in the underground districts. The decrease is explained by the use of more efficient light sources and better pole spacing.

Table XVII shows the cost information relative to the street lights shown in Table XVI.

TABLE XVII

Comparison of Annual Cost of Streetlighting Systems

Item	Existing Reference	Existing Amount	Proposed Reference	Proposed Amount
Contractual Services (P.G.&E.Co)				
a. Company & Joint Owned Facilities	1	$767,000	2	$644,000
b. City-owned Facilities	1	191,000	2	158,490
Deduction for Energy	1	488,000	2	553,000
		470,000		249,500
Contractual Services (Maintenance Contract)	1	69,000	2	111,235
Energy Cost (To Hetch Hetchy)	1	488,000	2	553,000
Total Expenditure	1	$1,027,000		$ 913,700

References: 1. Annual Report of Public Utilities Commission 1961-62 - Table 12
2. Summarized from Work Sheets

The annual cost of the proposed system which will adequately illuminate the City is $113,000 per year less than the cost of the inadequate existing system, excluding interest and other investment costs.

VII

RECOMMENDED METHODS OF FINANCING

VII. Recommended Methods of Financing

There are three possible ways of financing a street-lighting improvement program. These are:

a. Annual appropriations from the General Fund.

b. Assessment of Owners of adjacent property.

c. Sale of Municipal Bonds.

Since the work should be accomplished as quickly as possible and the sum required is large, annual appropriations would have the effect of increasing the tax rate for the next few years. This is, of course, undesirable.

Assessment proceedings for the financing of streetlighting has only been used on one known project in the City. In some instances, on major thoroughfares, this means would be a hardship on property owners. They would be compelled to pay for streetlighting systems of higher cost than those in other districts. Furthermore, much of our existing streetlighting has been installed at no direct cost to property owners. Assessment proceedings also require time which is undesirable.

Although the investment costs for a program financed by the sale of bonds are high, (See Table XV), it seems that this is the only practical approach to the problem.

It was shown that the proposed system would cost about $113,000 per year less than the existing system. This saving could be applied to the retirement of bonds. Assuming an initial

investment of $7,000,000.00, the lifetime costs of the existing and proposed systems are as follows:

A. Existing System (Inadequate)

$1,027,000.00 per year for 30 years ---- $30,810,000.00

B. Proposed System (Adequate)

$913,700.00 per year for 30 years ------ $27,411,000.00

Investment charges on $7,000,000.00
to be retired in 15 years at 3-1/2% --- $ 9,117,150.00

Total Cost in 30 years ---------- $36,528,150.00

Increased Cost over existing
in lifetime ---------- $ 5,718,150.00

Average Increase in Annual Cost-- $ 190,605.00

This increase in annual cost over a period of 30 years is about 24.7 cents per year per capita.

VIII

SUMMARY AND CONCLUSIONS

VIII. Summary and Conclusions

The results of the survey can be summarized briefly, as follows:

1. Existing lighting is below current recommended levels in most of the City.

2. A new rate proposed by the Pacific Gas and Electric Company for streetlighting service in residential areas is to the City's advantage. The Company should be instructed to proceed immediately with the improvement of lighting in such areas.

3. Other portions of the overhead districts require higher levels of illumination. The Pacific Gas and Electric Company rates are slightly higher than could be obtained through City-ownership for such service. The difference in cost is small, however, and only to the City's advantage in a long term of perhaps 30 years. Where police and traffic records indicate a need, the streetlighting should be improved as soon as possible. Where priorities are low, each case should be considered separately. The difference in cost of City and Utility Company ownership is small and will probably not offset the intangible losses in aesthetic values. Most streets in overhead districts will not have their appearances enhanced by more poles.

4. In the underground districts, any improvement of the streetlighting on a large scale will be of great financial advantage to the City.

5. A measure for a Bond Issue in the amount of $7,000,000.00 should be offered for approval of the electorate as soon as possible.

6. An adequate streetlighting system can be obtained for a total annual cost of$913,700 compared to the current annual cost of $1,024,000.00 for an inadequate system.

7. Exis ting adequate systems in underground districts that are owned by the Pacific Gas and Electric Company should be allowed to remain until it is deter- that they are fully depreciated. At that time, an analysis of current costs should be made to determine the best procedure to be followed for improvement.

Probably the most significant conclusion to be drawn from the survey is the importance of constantly analyzing the costs of operation and questioning practices of long standing.

The relationship between the Pacific Gas and Electric Company and the City in regard to streetlighting should be viewed as competitive. The situation at the present time is in favor of City ownership of the streetlighting in underground districts. In the years that follow the improvement program, the situation may change. In any event, the prices bid for streetlighting

by the Pacific Gas and Electric Company each year should be analyzed and compared with the prices the City obtains through its competitive bidding practices. Other factors being equal, the decisions on future ownership should be decided on an economic basis.

All streetlighting functions, except billing for energy, should be consolidated in the Department of Public Works, as the following related functions are now performed by that Department:

a. All City-owned streetlighting construction.

b. All traffic signal construction.

Great economies in construction are possible through the use of common conduits for signals and lighting.

c. All street construction.
Large savings in construction costs are possible through co-ordination of the streetlighting work with pavement reconstruction or street widening projects.

Consolidation of all streetlighting responsibility will simplify the operations in the following way:

Correspondence between departments will be almost eliminated. Under present arrangements, designs must be approved by the Public Utilities Commission. This requires at least two letters for each job. Complaints

are received by both departments and are referred back and forth with letters. Engineers of the Public Utilities Commission must seek information from the Department of Public Works before preparation of their annual budget. Enforcement of guarantees on new installations is awkward because maintenance is now administered by an agency different from that responsible for construction.

APPENDIX A

ELEMENTARY ILLUMINATING ENGINEERING

Light is conceived as a luminous flux emanating from a luminous source. The unit of luminous flux is the lumen and the illumination at a surface in the path of the flux is the flux density expressed in lumens per square foot commonly called foot-candles.

With most streetlighting luminaires less than 40% of the luminus flux produced by the lamp is distributed on the street between curb lines. A considerable amount is lost within the luminaire and much is radiated outside the useful zones.

Furthermore, light output drops off as lamps age and luminaires accumulate dirt. It is commonplace to lose about 30% of the light output of a luminaire due to these factors.

Consequently, only about 28% of the lumen output of a bare lamp is actually utilized. However, a large percentage of the lost light falls on areas outside the curb lines and serves the useful purposes of illuminating sidewalks and the fronts of buildings.

A typical San Francisco block is 600 feet long with a 38'-6" roadway. If this typical block is in a very quiet residential neighborhood, the IES recommends that it have an average illumination level of 0.2 foot-candle. Now the useful luminous flux is equal to the pavement area multiplied by the flux density, thus:

Pavement Area $600' \times 38.5' = 23{,}000$ sq. ft.

$0.2 \frac{\text{lumens}}{\text{sq.ft.}} \times 23{,}000 \text{ sq. ft.} = 4{,}600 \text{ lumens}$

In order to obtain 4,600 useful lumens

$$\frac{4600}{.28} = 16{,}400 \text{ lumens}$$

must be provided.

Since lamps come in a variety of sizes and light outputs, there is a wide choice of ways to illuminate the street. However, all choices do not provide a satisfactory or economical solution to the streetlighting problem.

It is possible to achieve good streetlighting for all of the categories proposed in the survey with the possible exception of Category A with similar spacings of electroliers. The different intensities required can be attained by the use of sources of proper light output. This concept is of considerable importance.

As stated, the customary unit of evaluation of a streetlighting system is the average foot-candle. A moment's reflection will disclose the pitfalls surrounding the improper use of the average foot-candle concept.

For example, a 600-foot block might be illuminated to the same average level with 5 - 4000 lumen units or a single 20,000

lumen unit. In the latter case, we can be certain that the system would be unsatisfactory, having a bright area around the electrolier and increasing darkness as the distance from the source increases. The law of inverse squares holds approximately for streetlighting. This means that the illumination decreases very rapidly with the distance from the light source.

If the City is to have a streetlighting system free from excessively bright areas separated by shadows, it is necessary to decide upon a reasonable spacing of the streetlights. A spacing of electroliers of about five times the mounting height of the source is frequently used as a rule of thumb in the design of streetlighting. It has been found that reasonable ratios of brightness to darkness prevail with such a spacing.

Since it is standard practice to illuminate intersections or points of traffic conflict above all else, the starting points of the streetlight spacing are fixed. Unfortunately, the block lengths in existence in San Francisco were not designed for optimum streetlight spacing in mind. Most blocks are too long for the use of electroliers only at the intersections and too short for the most economical spacing to be achieved for mid-block lighting. Moreover, as the widths of the streets vary over a wide range, it is not possible to establish a foot-candle level as a criterion for streetlighting.

It is possible, however, to establish a reasonable range each side of the ASA-IES recommendations and adapt these ranges to the categories listed previously.

In addition to the various block lengths, street widths, hills and other existing conditions that are conducive to non-uniform street lighting, about 46% of existing street lights are on wood poles and supplied from overhead wiring. If these poles are to be utilized to support street lights, certain compromises in spacing must be made if an excessive number of poles is to be avoided. Therefore, no recommendation can be made for luminaire spacing in overhead districts except the very general rule that it be approximately five times the mounting height.

The recommendations of the Illuminating Engineering Society are for minimum acceptable levels of illumination. The lowest recommended level of 0.2 foot-candle average for residential streets is higher than the existing illumination on most San Francisco streets. It will seem too high to many people.

The illumination should, however, not be judged by pedestrian observers with dark-adapted eyes. For example, bright moonlight has an average illumination level of about .02 foot-candles. Under certain circumstances, this level of illumination is satisfactory for pedestrian use. However, everyone has observed that it takes longer to identify an unknown object under low levels of illumination than otherwise. Time for identification of objects is not available to drivers.

The time available for seeing an object becomes shorter as vehicle speeds increase. H. R. Blackwell has been quoted[1] as

stating that at a viewing range of 200 feet along an asphalt pavement, the illumination requirements for positive identification was:

.34 foot-candle for an old automobile;
.40 foot-candle for a mannequin of a 12-year old girl (20% reflectance factor clothing);
1.8 foot-candles for a black poodle dog;
900. foot-candles for a brick.

Automobile headlights serve the purpose of providing the illumination needed to identify such objects on our streets. However, in many instances, headlights of oncoming vehicles cause glare that blinds drivers. Such glare is reduced when the streets are adequately lighted. Furthermore, there is a reduction in visual acuity with age. Persons 60 years of age only see about 74% as well as persons 20 years old.[2] It has been reported[3] that 6,000,000 drivers in the United States are over 65 years old. Consequently, street lighting systems should be designed with the problem of the older driver and pedestrian in mind.

Rain or fog are other factors that make evaluation of a street lighting system difficult. A wet pavement reflects light in narrow beams completely destroying the usual silhouette illumination that prevails in street lighting. Recognition of an obstacle can only take place by means of its surface detail which, of course, is only discernable with high levels of illumination.

[1] "The American City" June, 1961 - p. 147
[2] IES Handbook, p. 2-18
[3] "The American City" August, 1962 - p. 110

APPENDIX B-1

Street Lighting Construction Costs

A study was made of the prices bid for the installation of street lights under recent Department of Public Works Contracts. So that all the costs would be comparable, a standard spacing of 137 feet was assumed and the conduit and cable prices figured therefrom. Luminaire prices were taken from the latest General Electric Company price lists dated June 18, 1962.

There is a wide variation in the unit prices bid by the various contractors for each job. Average prices for individual items are of doubtful value due to this unbalance. However, when the prices bid for conduit, wire, street lights and controls are taken together and an average cost per street light determined, the results are representative of the actual cost.

Engineering and inspection costs are estimated at 5 percent of the construction cost.

TABLE B-1

Street Lighting Construction Costs

Type System	Estimated Construction Cost	Est. Engr. Cost	Estimated Total Cost
175W Steel Standard	$ 880.00	$44.00	$ 924.00
250W Steel Standard	885.00	45.00	930.00
400W Steel Standard	900.00	45.00	945.00
700W Steel Standard	975.00	49.00	1024.00
1000W Steel Standard	990.00	50.00	1040.00
175W Concrete Standard	980.00	49.00	1029.00
250W Concrete Standard	985.00	50.00	1035.00
400W Concrete Standard	1000.00	50.00	1050.00
700W Concrete Standard	1075.00	54.00	1129.00
1000W Concrete Standard	1090.00	55.00	1145.00
175W Trolley Pole	730.00	37.00	767.00
250W Trolley Pole	735.00	38.00	773.00
400W Trolley Pole	750.00	38.00	788.00
700W Trolley Pole	775.00	39.00	814.00
1000W Trolley Pole	810.00	41.00	851.00

APPENDIX B-2

Annual Costs of Street Lighting

The annual costs of street lighting can be separated into three parts:

a. Payments to Pacific Gas and Electric Company.

b. Energy Costs.

c. Maintenance Costs.

A. Payments to the Pacific Gas and Electric Company

The Public Utilities Commission of the City enters into an annual contract with the Pacific Gas and Electric Company for furnishing street lighting service. As part of the contract, rates are quoted for all classes of street lighting including both Company and City-owned systems. The Company-owned systems are maintained by the Company. City-owned systems are maintained under a separate contract. Energy is supplied from the Hetch Hetchy system under identical terms for both classes of ownership.

When the rates bid for a City-owned system are corrected for the credit for Hetch Hetchy energy, there is a residue paid to the Pacific Gas and Electric Company. This residue is supposed to compensate the Company for its investments in distribution equipment.

B. Energy Costs

Since Hetch Hetchy energy is used for Company-owned as well as City-owned street lights, it is not a factor in the analysis except in the determination of the most efficient sources. Energy not used in street lighting has a ready sale to other City agencies or the industrial customers of the Public Utilities Commission.

The cost of delivering Hetch Hetchy energy to the street lights is a direct cost and is paid to the Pacific Gas and Electric Company.

Each of the rates for street lighting service is corrected in the amount of $ .01345 per KWH for the energy credit to the City. The wheeling or delivery charge of $ .006421 per KWH is then added to arrive at the actual payment to the Pacific Gas and Electric Company.

C. Maintenance Costs

Company-owned street lights are maintained by the Company and all costs are included in the rate schedules.

City-owned street lights are maintained under an annual contract. Bid prices are provided for most normal maintenance such as relamping, cleaning and painting. Trouble shooting, damage repair and other non-routine repair work is paid for on a time and material basis.

The annual maintenance costs shown in the analysis are based on changing the mercury-vapor lamps every 12,000 hours (about 3 years). The existing incandescent lamps are changed every 2,000 hours. The costs of such lamp changing are taken from the prices bid under the current maintenance contract. Non-routine maintenance was estimated on the basis of the past two contracts and averaged about $2.90 per street light. It is probable that this cost will be lowered in the future by the use of simpler circuits.

It should be pointed out that individual outages and broken glassware are repaired by the Pacific Gas and Electric Company under the rate schedules regardless of ownership.

APPENDIX B-3

Investment Costs

In any improvement program, it is desirable to determine that the result is worth the investment. The economic return on money invested in street lighting is difficult to compute. Certainly, the expected decrease in traffic accidents and street crime has an economic value. However, since street lighting can be purchased from the Pacific Gas and Electric Company on an annual basis with no initial investment or obtained through the letting of public contracts for which substantial payments are necessary, there is a necessity for justifying any amount invested.

For this analysis, it was assumed in computation of costs that the money would be obtained from the sale of bonds. Consultation with the Controller's office disclosed that it was expected that such bonds would be retired in 15 years and that we should compute interest at the rate of 3-1/2%.

Thus the annual cost of our investment is an amount that would repay the original cost plus interest at 3-1/2% in 15 years.

The cost of preparation of contract plans, specifications and inspection are included as part of the initial investment.

Based on the foregoing, the annual cost of $1,000.00 is $86.83 for 15 years.

In part of the analysis, this annual cost is averaged over the 30-year life of a street lighting system.

TABLE B-3

Investment Costs for Street Lighting Systems

Type System	Initial Cost Per Unit	Engineering and Inspection	Total Unit Cost	Annual Cost 15 Years	Annual Cost 30 Years
175W Steel Poles	$ 880	$ 44	$924	$80.00	$40.00
250W Steel Poles	885	45	930	80.50	40.25
400W Steel Poles	900	45	945	82.00	41.00
700W Steel Poles	975	49	1024	89.00	44.50
1000W Steel Poles	990	50	1040	90.00	45.00
175W Conc. Poles	980	49	1029	89.00	44.50
250W Conc. Poles	985	50	1035	90.00	45.00
400W Conc. Poles	1000	50	1050	91.00	45.50
700W Conc. Poles	1075	54	1129	98.00	49.00
1000W Conc. Poles	1090	55	1145	100.00	50.00
175W Trolley Poles	730	37	767	66.00	33.00
250W Trolley Poles	735	38	773	67.00	33.50
400W Trolley Poles	750	38	788	68.00	34.00
700W Trolley Poles	775	39	844	73.00	36.50
1000W Trolley Poles	810	41	851	74.00	37.00
175W Wood Pole	200	10	210	18.00	9.00
250W Wood Pole	205	11	216	18.60	9.30
400W Wood Pole	220	11	230	20.00	10.00

APPENDIX B-4

Taxes

In the case of Pacific Gas and Electric Company ownership of a street lighting system, a portion of the money paid to the Company is returned to the City as a result of taxes on the street lighting equipment. The exact amount of the tax on existing systems is difficult to determine because of the methods of reporting and assessing.

However, it is possible to estimate the tax on new equipment which is the significant feature in the comparison of costs of City and Company ownership. In this analysis, a 30-year life is assumed for street lighting systems with a straight-line depreciation of value from the actual installed cost to an assumed salvage value at the end of life. In San Francisco, the ratio of assessed to full cash value of locally assessable property is .242 [1]. However, assessment of utility company property is by the Board of Equalization. The ratio applied to the property of the Pacific Gas and Electric Company is estimated by their engineer to be about .40.

Using the assumptions stated above and the estimated construction costs from Table B-1, it is possible to estimate the taxes that the Pacific Gas and Electric Company should pay. This information is summarized in Table B-4. The existing tax rate of $9.39 per $100.00 of assessed valuation was used.

[1] California State Board of Equalization - Annual Report 1961-62, p.12

TABLE B-4

Property Taxes on Street Lighting Systems

Type System	Unit Investment	Average Value (30 Years)	Average Assessed Value (30 Years)	Average Annual Taxes (30 Years)
175W Steel Std.	$ 880	$ 420	$ 168	$ 15.80
250W Steel Std.	885	423	169	15.90
400W Steel Std.	900	430	172	16.10
700W Steel Std.	975	465	182	17.10
1000W Steel Std.	990	475	190	17.80
175W Conc. Std.	980	470	188	17.60
250W Conc. Std.	985	472	189	17.70
400W Conc. Std.	1000	480	192	18.00
700W Conc. Std.	1075	520	208	19.60
1000W Conc. Std.	1090	525	210	19.70
175W Trolley Pole	730	365	146	13.70
250W Trolley Pole	735	367	147	13.80
400W Trolley Pole	750	375	150	14.00
700W Trolley Pole	775	387	155	14.50
1000W Trolley Pole	810	405	162	15.20
175W Wood Pole	200	100	40.	3.75
250W Wood Pole	205	103	41.	3.85
400W Wood Pole	220	110	44.	4.13

APPENDIX B-5

Miscellaneous Payments to the City by the Pacific Gas and Electric Company

It has been the custom for many years for the Pacific Gas and Electric Company to pay to the Municipal Railway and its predecessor an annual fee for permission to support its street lights on Municipal Railway trolley poles. Since this small fee has the effect of reducing tax support of the railway, it must be included in a cost analysis of the street lighting systems.

The fee paid by the Pacific Gas and Electric Company varies from $1.50 per year to $3.50 per year depending on location and type of support. The amounts are shown in the semi-annual bills submitted to the Company by the Municipal Railway. The amounts shown in our cost study correspond to those being paid at the present time.